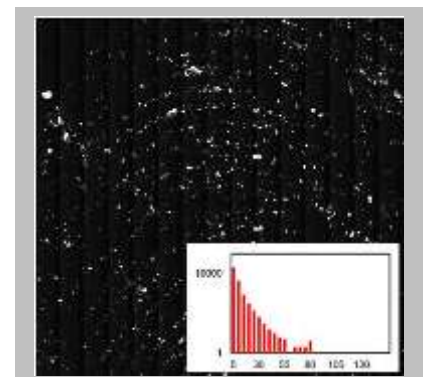# The Geometric Morphology of Explosive Residues and Their Role in Stand-Off Optical Detection of Explosives

Matthew Aernecke, Michelle Clark, and Roderick Kunz – MIT Lincoln Laboratory

Augustus Way Fountain III - ECBC

Detecting explosive threats in the field typically depends on indirect indicators of the threat – termed "signatures" – that have been linked to the presence of a larger concealed quantity of material.  Explosive detection techniques that use chemical analysis to identify threats rely on signatures that consist of residues of bulk material deposited onto accessible surfaces.  In this study, we focused on two types of opportunistic chemical signatures strongly associated with IED activity:  latent fingerprints contaminated with explosive particles and spills associated with the packaging and transport of IED precursor materials.  To generate the fingerprint samples, we staged actual IED assembly activities and sampled the fingertips of the bomb maker during various stages of the process.  For the transport scenario, we transferred 1000 pounds of precursor material into non-descript packaging and loaded it onto the back of a flatbed truck.  We then characterized both of these signatures in terms of their likelihood of occurrence, the quantity of material deposited, and the geometric morphology of the deposited residue.



**Optical microscope image and particle size histogram (inset) of a latent fingerprint contaminated with particles of TNT.**

The geometric morphology of an explosive residue is an often overlooked, yet critical component to analyzing the performance of various stand-off detection systems.  In order to project the success of a sensor within a particular CONOP, it is vital to understand the types of samples it may encounter and the likelihood that they will actually be available for detection.  Our analysis showed that for most systems to be successful at detecting fingerprint residues they must be able to resolve individual particles around 100 microns in diameter at modest stand-off distances (10 meters).  Larger signatures, such as those observed in the vehicle exercise, have a high probability of occurrence and have average signature sizes in the 3 mm range. Thus, in order to have a reasonable chance of success in either scenario, these systems must be capable of performing sub-pixel detections at very low pixel fill fractions (<1%) with the potential added burden of high magnification optics.  In the future, it will be critical to field test candidate detection systems on samples with morphologies that emulate those we have observed here.

For more information, contact: Matthew J. Aernecke, aernecke@ll.mit.edu, 781-981-4367

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